Reactor Simulator Testing Overview

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Background

Nuclear Systems Team

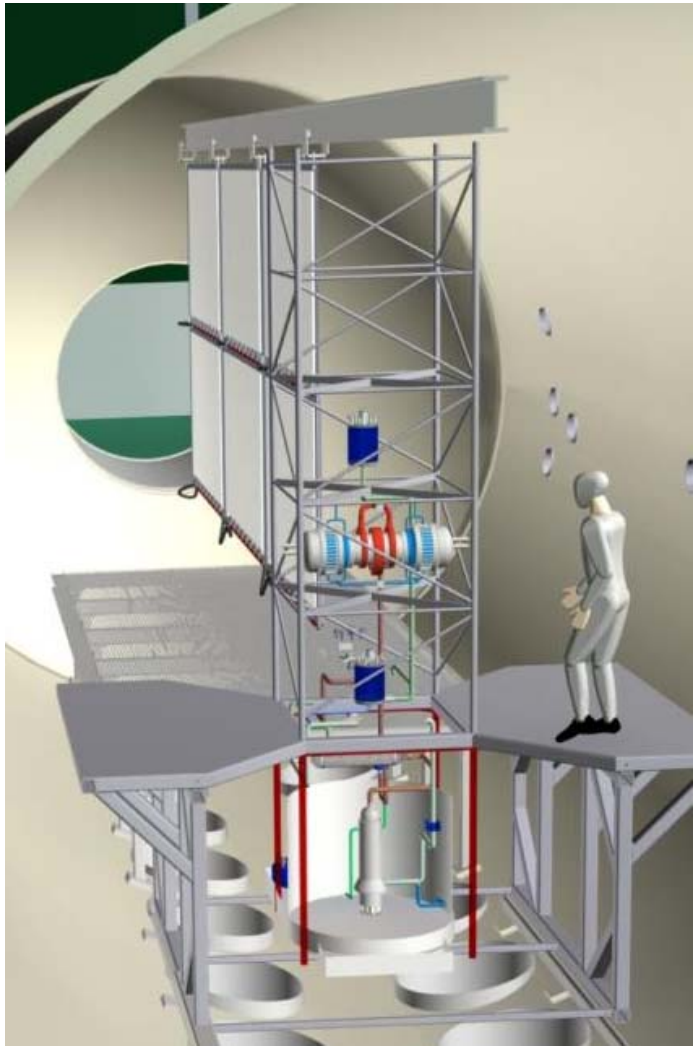
- focuses on technology development for a variety of space nuclear systems
  - state-of-the-art capability in non-nuclear testing (electric heaters to closely mimic the static and dynamic thermal performance of nuclear fuels)
  - fission reactor and radioisotope systems.
  - applications of surface and spacecraft power & nuclear propulsion(thermal, electric, advanced concepts like fusion, plasma, etc.)

Program/Project Support

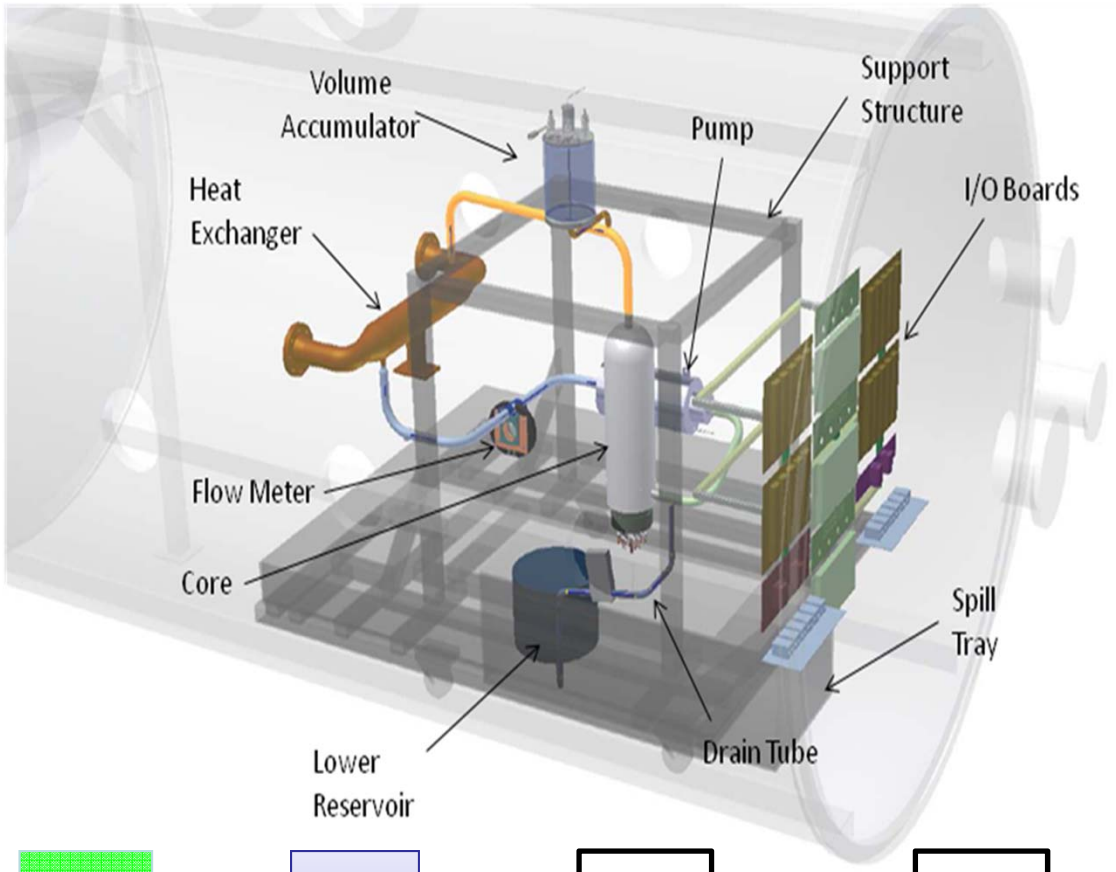
- primary Program/Project support
  - Fission Surface Power efforts supported by ETDD through the Nuclear Systems Office. The MSFC program lead is Mike Houts/VP33. Technology Demonstration Unit (TDU)
  - TDU is an end-to-end system test of a reactor simulator (RxSim), Power conversion Unit, and Heat Rejection System in a thermal vacuum.
  - TDU is intended to demonstrate the major element of a notional FSPS.
  - RxSim perform integrated testing of the TDU components

Scope Reactor Simulator

Technology Demonstration Unit



Reactor Simulator



Gas and Vacuum Racks

Facility Gas, Vacuum, & Power Panels

Power Rack

Data and Control Rack

Reactor Simulator Testing Overview

OBJECTIVE

- integrated testing of the TDU components

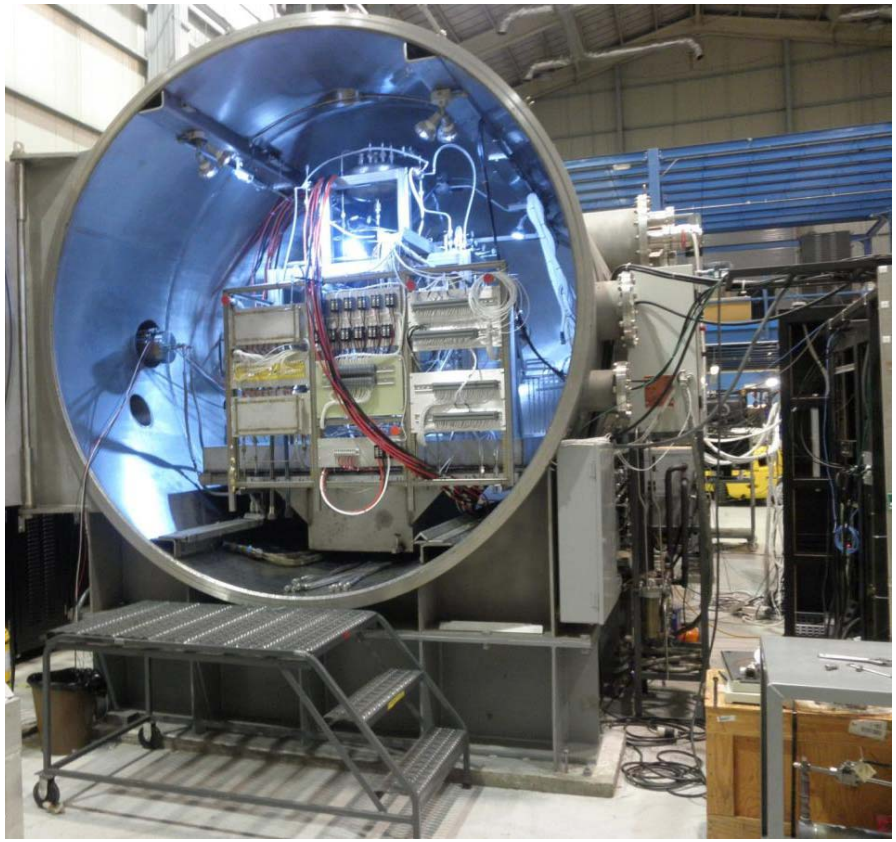
TESTING SUMMARY

- verify the operation of the core simulator, the instrumentation and control system, and the ground support gas and vacuum test equipment.
- thermal test heat regeneration design aspect of a cold trap purification filter
- pump performance test at pump voltages up to 150 V (targeted mass flow rate of 1.75 kg/s was not obtained in the RxSim at the originally constrained voltage of 120 V)

TESTING HIGHLIGHTS

- gas and vacuum ground support test equipment performed effectively for NaK fill, loop pressurization, and NaK drain operations.
- instrumentation and control system effectively controlled loop temperature and flow rates or pump voltage to targeted settings.
- cold trap design was able to obtain the targeted cold temperature of 480 K. An outlet temperature of 636 K was obtained which was lower than the predicted 750 K but 156 K higher than the cold temperature indicating the design provided some heat regeneration.
- ALIP produce a maximum flow rate of 1.53 kg/s at 800 K when operated at 150 V and 53 Hz.

Reactor Simulator Integrated Setup



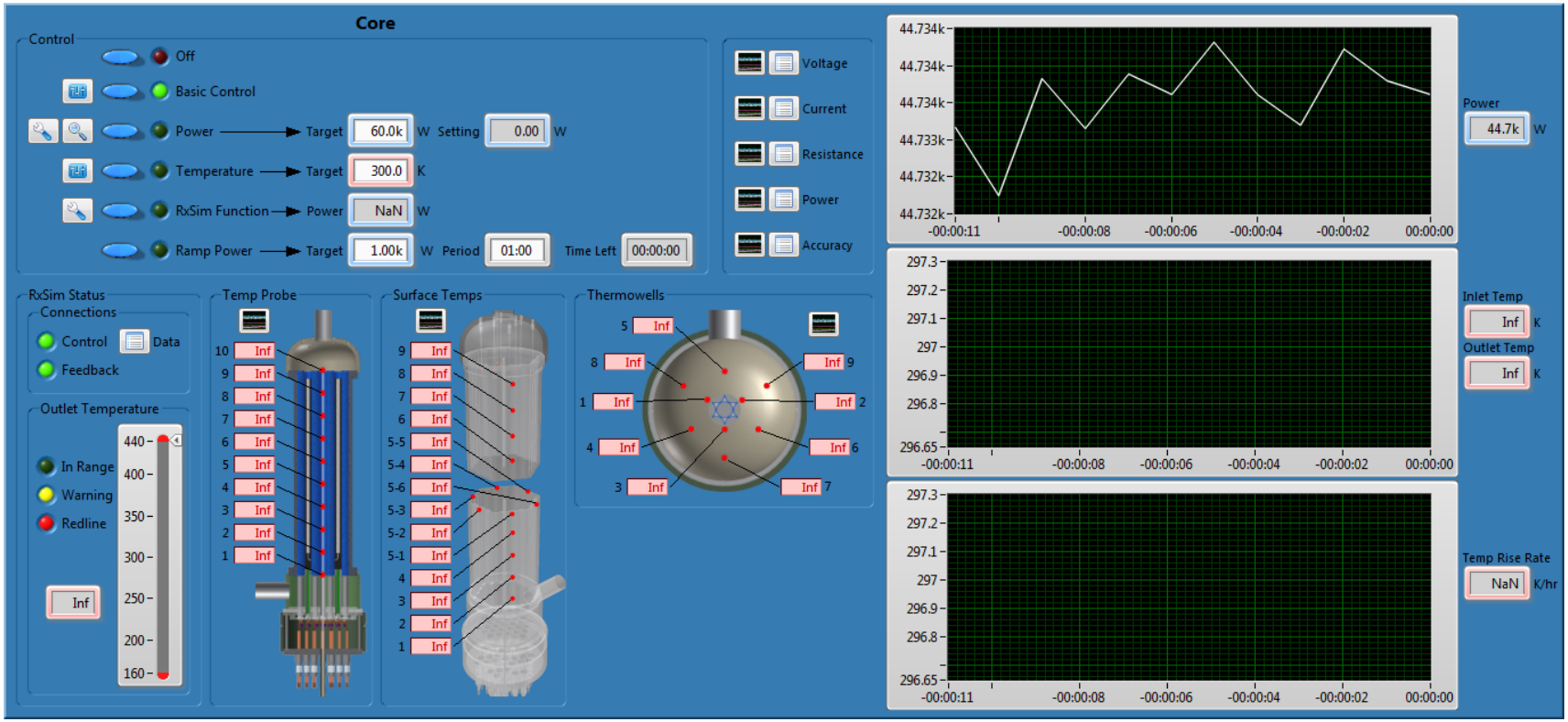
Reactor Simulator in Chamber

User Interface Controls & Gas & Vacuum Panels

Core & Pump Power Panels

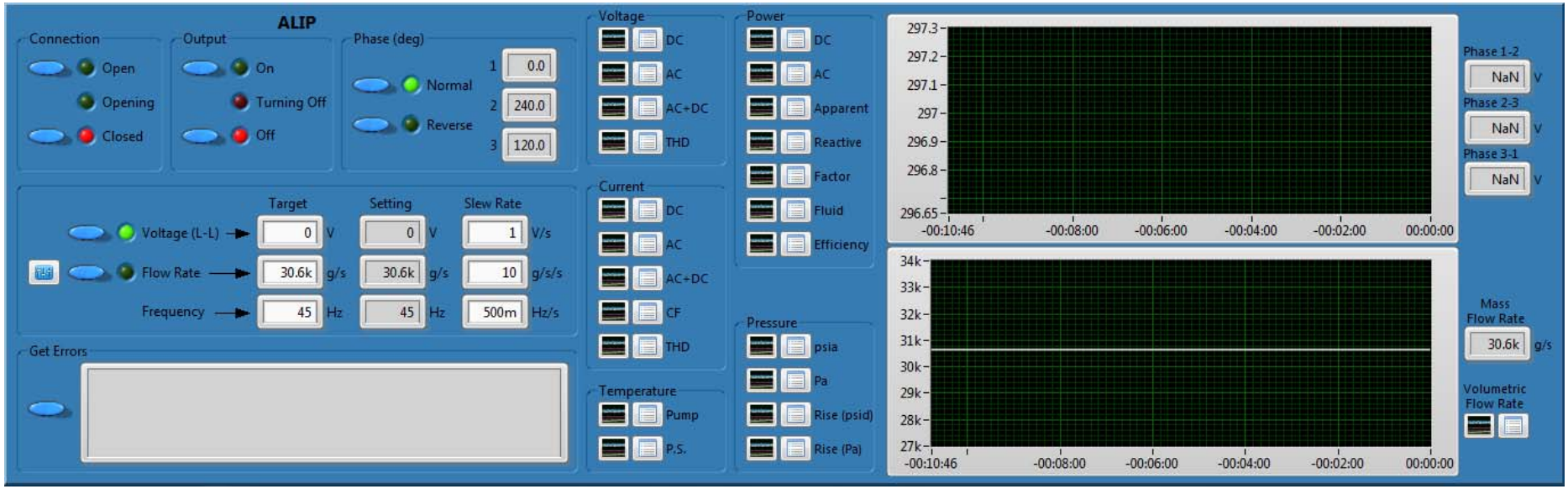
Core Simulator Control System Modes

1. **Basic:** Control current (I) and voltage (V) settings of each heater zone in the core simulator
2. **Power:** Control total power setting for the core simulator
3. **Power Ramp:** Control total power from starting point to new set point over period of time.
4. **Temperature:** Control the NaK outlet temperature of the core simulator.
5. **Reactor Simulator Function:** Remotely control core power by an external Labview real time controller that runs a Simulink model simulating the feedback response of a nuclear reactor.

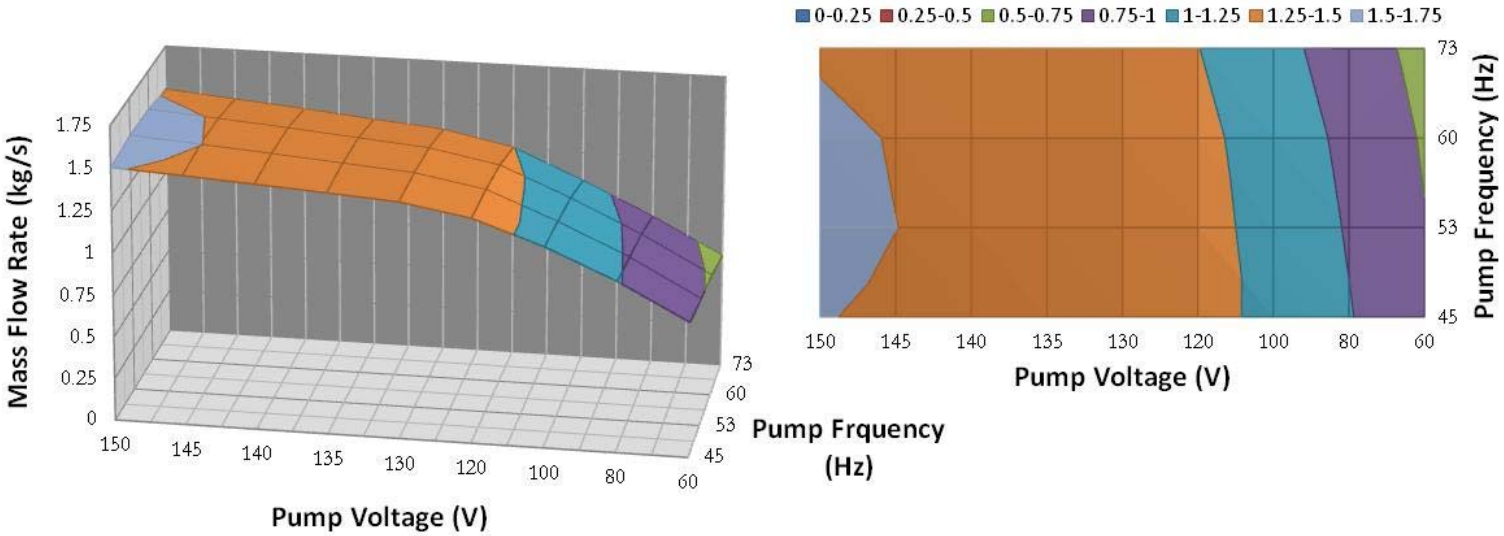


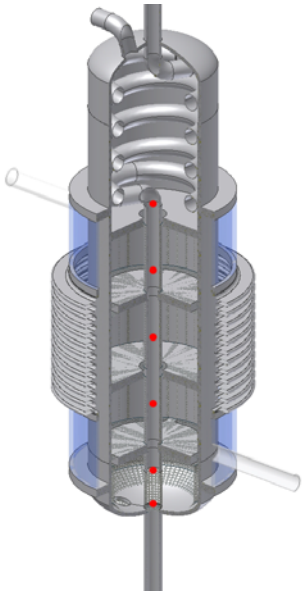
ALIP Control System Modes

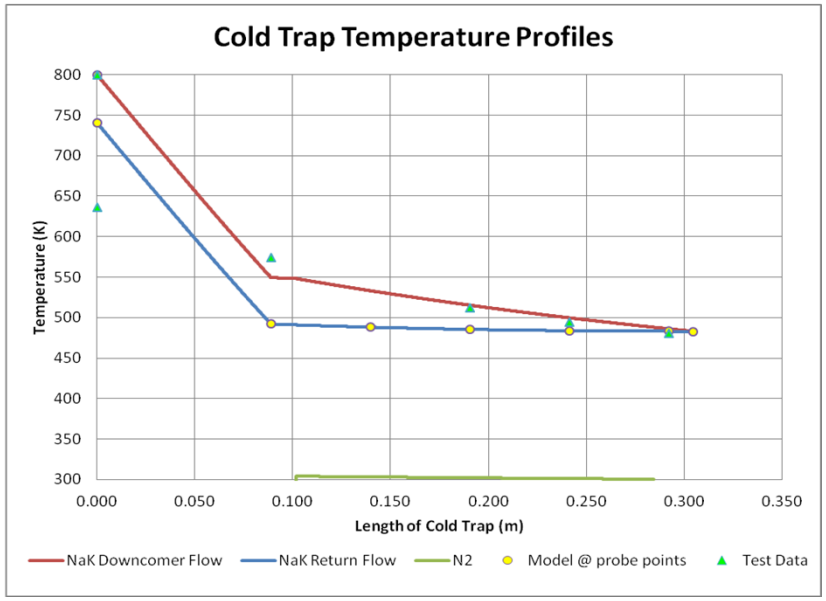
1. **Voltage:** control the line-line voltage setting of the ALIP power supply
2. **Flow Rate:** control the NaK mass flow rate



Testing Highlights







Outcomes

- gas and vacuum ground support test equipment performed effectively for NaK fill, loop pressurization, and NaK drain operations.

- instrumentation and control system effectively controlled loop temperature and flow rates or pump voltage to targeted settings.

- cold trap design was able to obtain the targeted cold temperature of 480 K. An outlet temperature of 636 K was obtained which was lower than the predicted 750 K but 156 K higher than the cold temperature indicating the design provided some heat regeneration.

- ALIP produce a maximum flow rate of 1.53 kg/s at 800 K when operated at 150 V and 53 Hz.

Questions?

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